

A CASE FOR HYPOGRAVITY STUDIES ABOARD ISS

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Future human space exploration missions being contemplated by NASA and other spacefaring nations include some that would require long stays upon bodies having gravity levels much lower than that of Earth. While we have been able to quantify the physiological effects of sustained exposure to microgravity during various spaceflight programs over the past half-century, there has been no opportunity to study the physiological adaptations to gravity levels between zero-g and one-g.

We know now that the microgravity environment of spaceflight drives adaptive responses of the bone, muscle, cardiovascular, and sensorimotor systems, causing bone demineralization, muscle atrophy, reduced aerobic capacity, motion sickness, and malcoordination. All of these outcomes can affect crew health and performance, particularly after return to a one-g environment.

An important question for physicians, scientists, and mission designers planning human exploration missions to Mars ($3/8$ g), the Moon ($1/6$ g), or asteroids (likely negligible g) is: What protection can be expected from gravitational levels between zero-g and one-g? Will crewmembers deconditioned by six months of microgravity exposure on their way to Mars experience continued deconditioning on the Martian surface? Or, will the $3/8$ g be sufficient to arrest or even reverse these adaptive changes? The implications for countermeasure deployment, habitat accommodations, and mission design warrant further investigation into the physiological responses to hypogravity.

It is not possible to fully simulate hypogravity exposure on Earth for other than transient episodes (e.g., parabolic flight). However, it would be possible to do so in low Earth orbit (LEO) using the centrifugal forces produced in a live-aboard centrifuge. As we're not likely to launch a rotating human spacecraft into LEO anytime in the near future, we could take advantage of rodent subjects aboard the ISS if we had a centrifuge that could accommodate the rodent subjects for extended periods (weeks to months) at various hypogravity levels. Experiments aboard such a centrifuge could provide important insight into human exploration questions and simultaneously answer fundamental questions in gravitational physiology.